DOCUMENT RESUME

ED 035 294 EM 007 658

AUTHOR	Cooley, William W.
TITLE	Computer-Assisted Instruction in Statistics. Technical Report.
INSTITUTION	Pittsburgh Univ., Pa. Learning Research and Development Center.
SPONS AGENCY	Office of Naval Research, Washington, D.C. Personnel and Training Branch.; Office of Naval Research, Washington, D.C. Psychological Sciences Div.
PUB DATE	69
NOTE	24p.; Paper presented at Conference on Statistical Computation, University of Wisconsin (Madison, April 30, 1969)
EDRS PRICE	EDRS Price MF-$0.25 HC-$1.30
DESCRIPTORS	Computational Linguistics, *Computer Assisted Instruction, Computer Based Laboratories, *Computer Oriented Programs, Computers, Computer Science, *Computer Science Education, Instruction, Instructional Innovation, Instructional Media, Programing, *Statistics, Teaching Machines, Technical Education, Time Sharing
IDENTIFIERS	Monte Carlo, PLANIT, University of Pittsburgh

ABSTRACT

A paper given at a conference on statistical computation discussed teaching statistics with computers. It concluded that computer-assisted instruction is most appropriately employed in the numerical demonstration of statistical concepts, and for statistical laboratory instruction. The student thus learns simultaneously about the use of computers and those concepts which are best demonstrated through the use of computers--for example, multivariate analysis. In an introductory course on statistical inference, computers are used for weekly laboratory exercises, generating random numbers, empirical theoretical distributions, Monte Carlo studies, means, and the like. However, direct use of the computer in instruction--namely directions and questions included on-line--is at this time too expensive. As cost of computer time decreases it should become more feasible. Future planning centers around more flexible student terminals, and the development of a battery of computer-administered tests to further individual instruction. (BB)

EM007658

ED035294

THIS DOCUMENT HAS BEEN REPRODUCED AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL OFFICE OF EDUCATION POSITION OR POLICY.

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION
THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY

ED035294

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL OFFICE OF EDUCATION POSITION OR POLICY.

COMPUTER-ASSISTED INSTRUCTION IN STATISTICS

William W. Cooley

Learning Research and Development Center

University of Pittsburgh

1969

The research reported herein was performed under Contract Nonr-624(18)

Personnel and Training Branch

Psychological Sciences Division

Office of Naval Research

This document has been approved for public release and sale; Its distribution is unlimited.

Computer-Assisted Instruction in Statistics[1]

William W. Cooley
Professor of Education and Computer Science
University of Pittsburgh

I am pleased that the organizers of this Conference on Statistical Computation saw fit to include a session on the teaching of statistics with computers. Certainly most of the statistical-computer effort to date has been directed toward research applications. My thesis is that we can and should provide computer experience as part of instruction in statistical methodology, and that such experiences can be designed to facilitate the learning of basic principles of statistical inference as well as teach how to use the computer in the analysis of data.

The general problem of using the computer as an instructional device has been under investigation for about 10 years. Two recent surveys of this field, readily available to this audience, are the articles in the September, 1968 issue of Datamation by Zinn and others and the Atkinson and Wilson (1968) article in Science. Most generally called computer-assisted instruction (CAI), the field has grown from a vague idea in 1958 to a multimillion dollar research enterprise in 1969.

---

[1]Paper prepared for Conference on Statistical Computation, University of Wisconsin Computing Center, April 30, 1969. The research reported herein was performed pursuant to Contract Nonr-624(18) Personnel and Training Branch, Psychological Sciences Division, Office of Naval Research. Additional support was provided by the Office of Education, U. S. Department of Health, Education, and Welfare.

A variety of different approaches to CAI has emerged from all this activity. In general they form a spectrum from very rigidly controlled student-computer interactions such as drill and practice, to systems which allow the student to manipulate and operate on aspects of the subject matter through techniques such as simulation and gaming.

The cost of CAI makes it impossible at this time to justify its use for purely instructional purposes. As an object of research CAI is a justifiable enterprise on the assumption that computer costs will continue to go down (relative to instructional alternatives) while its effectiveness will continue to increase, so that someday CAI will be cost-effective for at least some kinds of instruction. There is some disagreement as to how far away that someday is (see, for example, Oettinger and Marks, 1968), but most agree it is coming.

One situation in which CAI is feasible today is where the student must learn how to use the computer anyway, and where such learning is a by-product of his computer-assisted instruction in the primary subject. Certainly an example of such a subject area is data analysis and statistical inference. An example of such an instructional system is the one developed at System Development Corporation (Rosenbaum, 1968; Rosenbaum, Feingold, Frye and Bennik, 1967). Using the PLANIT language, they wrote three types of student exercises:

1) tutorial-dialogue: a programmed instruction mode with computer questions and student answers.

2) exposition: primarily Monte Carlo type experiments where the student-computer "conversations" allow the student to specify the kind of experiment he wishes to perform and then define the parameters for that experiment.

3) computational exercises: data analysis experiences with contrived or randomly generated data.

After two years of studying these three CAI modes the authors concluded that "CAI is most appropriately employed in the numerical demonstration of statistical concepts and for statistical laboratory exercise instruction" (Rosenbaum, et. al., 1967, p. 1).

In the fall of 1967 we[2] began to develop a computer laboratory for statistics instruction which took advantage of the availability of the University of Pittsburgh's time-sharing system. Today we are providing two kinds of experiences in these computer lab sessions. Monte Carlo studies are employed in which the student can examine the sampling distributions of the statistic he is studying in class and note the effects which occur as a result of varying parameters. The other type of laboratory experience is in data analysis. Here the computer takes on the arithmetic chores and frees the student's intelligence for considerations such as the selection of appropriate variables and samples, choice of the statistical program to be applied, and interpretation of the results.

---

[2]Colleagues and students who have helped me develop this approach are Paul R. Lohnes, Richard Ferguson, James Carlson, Paul Stieman, and Anthony Nitko. I am also indebted to Robert Glaser, Director of LRDC, for some financial support and personal encouragement.

Before examining these laboratory exercises in detail, it would be useful to describe the time-sharing computer system on which they have been implemented. At the University of Pittsburgh we have the IBM System/360, model 50 with 131K main storage (2 micro-second cycle time), a million byte large capacity storage (8 micro-second cycle time) and the 2314 disc with over two hundred million byte capacity. The Pitt Time Sharing System currently supports up to fifty simultaneous users most of whom operate from 2741's on dedicated lines. One feature of the PTS software which we use most heavily in this work is the time-sharing editor. The editor proves very useful for the initial preparation of source programs and for the continuous creation and editing of data for subsequent analyses. The FORTRAN IV compiler is available on the system, so with the editor we were able to adopt readily our existing statistical FORTRAN batch programs for interactive mode.

Programs and data files are stored on the disc and can be loaded or attached with very simple, typed commands. Additional data for analysis can be entered from the terminal, from cards taken to the Computer Center, or from tapes stored at the Center. When the user logs on, he declares how much core he will need for his current work. Up to 131K bytes can be allocated if core is available. Most applications seem to use 16K or 32K bytes of core.

Introduction to Statistical Inference

Our first course in statistical inference serves about 75 to 100 graduate students in education per trimester. Each student has

a weekly laboratory exercise which he does at his convenience by using one of several 2741 terminals on the campus to which he has access on a sign-up basis. The mimeographed directions for each exercise relate the lab to the lectures and the text, provide the necessary direction for terminal operation, and present questions regarding the computer output which the student answers after he has completed his work at the terminal. At first we tried to build directions and questions to be answered on-line into the computer programs, but we have concluded that this is too inefficient of computer time and terminal time. If, someday, computer costs come down and the terminal queue is not a problem, more tutorial-type interactions can be provided. Meanwhile we continue to examine the problem of allocating course content to lecture, tests, mimeographed handouts and computer exercises. Let us turn now to a description of those exercises.

The first lab provides experience with simple data manipulations such as transformations and descriptive statistics using a dataset stored on disc for this purpose. Those data are from a large educational survey conducted at the University of Pittsburgh, called Project TALENT. This provides the student access to a random sample of American high school students. He can select variables and subsamples (e.g., male or female) as he chooses.

Then the student moves through a series of computer experiments designed to familiarize him with:

(1) random number generation;

(2) empirical and theoretical distributions;

(3) sample statistics and population parameters;

(4) Monte Carlo study of sample variances;

(5) symmetric and nonsymmetric binomial distributions;

(6) central limit theorem and the normal distribution;

(7) sampling distribution of the mean;

(8) the t-distribution, power, type I and II errors; and

(9) sampling distribution of the correlation coefficient.

Experience with data analysis is also provided at appropriate points in the sequence. Students either enter their own data or use Project TALENT data for exercises with chi square, t-test, and correlation. A current evaluation of this course suggests that the data analysis portion should be expanded and some of the initial random number demonstrations be shifted to filmed presentations of dice and other "more concrete" experiments before turning to Monte Carlo experiments on the computer.

Printout 1 illustrates a Monte Carlo study of the t-distribution and Printout 2 illustrates a correlation analysis, where the student centers the data from the terminal. With respect to the computer programs that have been developed for this lab, a batch processing version of them is available in a new Wiley text (Lohnes and Cooley, 1968).

Introduction to Multivariate Analysis

The other statistics course in which we have been using the time-sharing system is a two-semester sequence in multivariate analysis.

Here the emphasis for the computer lab has been on providing data analysis experience for students from many divisions of the University whose interests are very applied. They want to know how to select, compute and interpret multivariate statistics in given research situations.

As each multivariate technique is introduced, the student is responsible for conducting a computer analysis of his own, using either the Project TALENT dataset stored on disc or appropriate data from his own field, if available. Table 1 describes the function of each avaiable program and Figure 1 indicates the input/output compatibility which exists in this system. Printout 3 illustrates the first page of a small discriminant analysis example. As the student moves through an analysis sequence (e.g., EDIT, CORREL, PRINCO, ROTATE), he catalogs and stores intermediate output on disc.

Of course if the objectives of the instruction were more in the direction of mathematical statistics than applied, the building blocks for such a computer lab could be matrix operations rather than specific statistical techniques. However, for the applied course, our approach allows the student to focus on concerns such as selection and interpretation, which are closer to his needs than would be, say, "reinventing" the matrix algebra for canonical correlation every time he was interested in exploring the relationships between two sets of variables.

Plans for the Future

Following extensive use of the CAI laboratory exercises in statistics developed by the project, future efforts will be devoted to further increasing the effectiveness of the laboratory. Two avenues will be explored: (a) One is to investigate the use of a more flexible student terminal. Monte Carlo experiments will be moved to a Sanders CRT terminal in order to see whether they are more effective than they have been with a typewriter-terminal approach. (b) The other is the development of a battery of computer-administered tests which will help to further individualize instruction in statistical inference. At the present time, although students work individually at a terminal, all students take the same laboratory exercise in the same week and have the same lecture and assignment. The long-range intent behind the implementation of a computer testing procedure is to redesign the course into a type of individually prescribed instruction in which the computer does the testing, supplies the laboratory experiences, and indicates suggested readings and paper-and-pencil exercises based on the outcomes of the computer-administered tests.

As I examine systems such as The Augmented Statistician (System Development Corporation, 1967) designed to provide the social scientist with interactive statistical programs, it seems clear that the instructional and interactive production systems are heading toward similar goals. So I shall conclude as I began, with an expression of thanks to our hosts who have brought us together for this exchange of ideas on statistical computation.

References

Atkinson, Richard C., and Wilson, H. A. Computer-assisted instruction. Science, Oct. 1968, 73-77.

Cooley, William W., and Lohnes, Paul R. Multivariate Procedures for the Behavioral Scientist. New York: John Wiley, 1962.

Lohnes, Paul R., and Cooley, William W. Introduction to Statistical Procedures: with Computer Exercises. New York: John Wiley, 1968.

Oettinger, Anthony and Marks, Sema. Educational technology: new myths and old realities. Harvard Educational Review, Fall 1968.

Rosenbaum, Joseph. Dialogues for elementary statistics instruction via computer. Santa Monica: System Development Corporation, 1968.

Rosenbaum, Joseph, Feingold, S. L., Frye, L. H., and Bennik, F. D. Computer-based instruction in statistical inference. Santa Monica: System Development Corporation, 1967.

System Development Corporation. The Augmented Statistician. Santa Monica: System Development Corporation, 1967.

Zinn, Karl L. Instructional uses of interactive computer systems. Datamation, Sept. 1968, 22-27.

TABLE 1

Multivariate Programs on the System

CANON	Canonical correlation
CLASIF	Multivariate normal classification
COEFF	Factor score coefficients
CORREL	Correlation
COVAR	Covariance analysis
DISCRM	Multiple group discriminant analysis
FACDIS	Factorial discriminant analysis
FACTOR	Extraction of arbitrary factorial analysis
FSCORE	Factor scores
MANOVA	Multivariate analysis of variance
MULTR	Multiple correlation
PARTL	Multiple partial correlation
PRINCO	Principal components
ROTATE	Varimax or quartimax rotation

These programs were adopted from Cooley and Lohnes (1962).

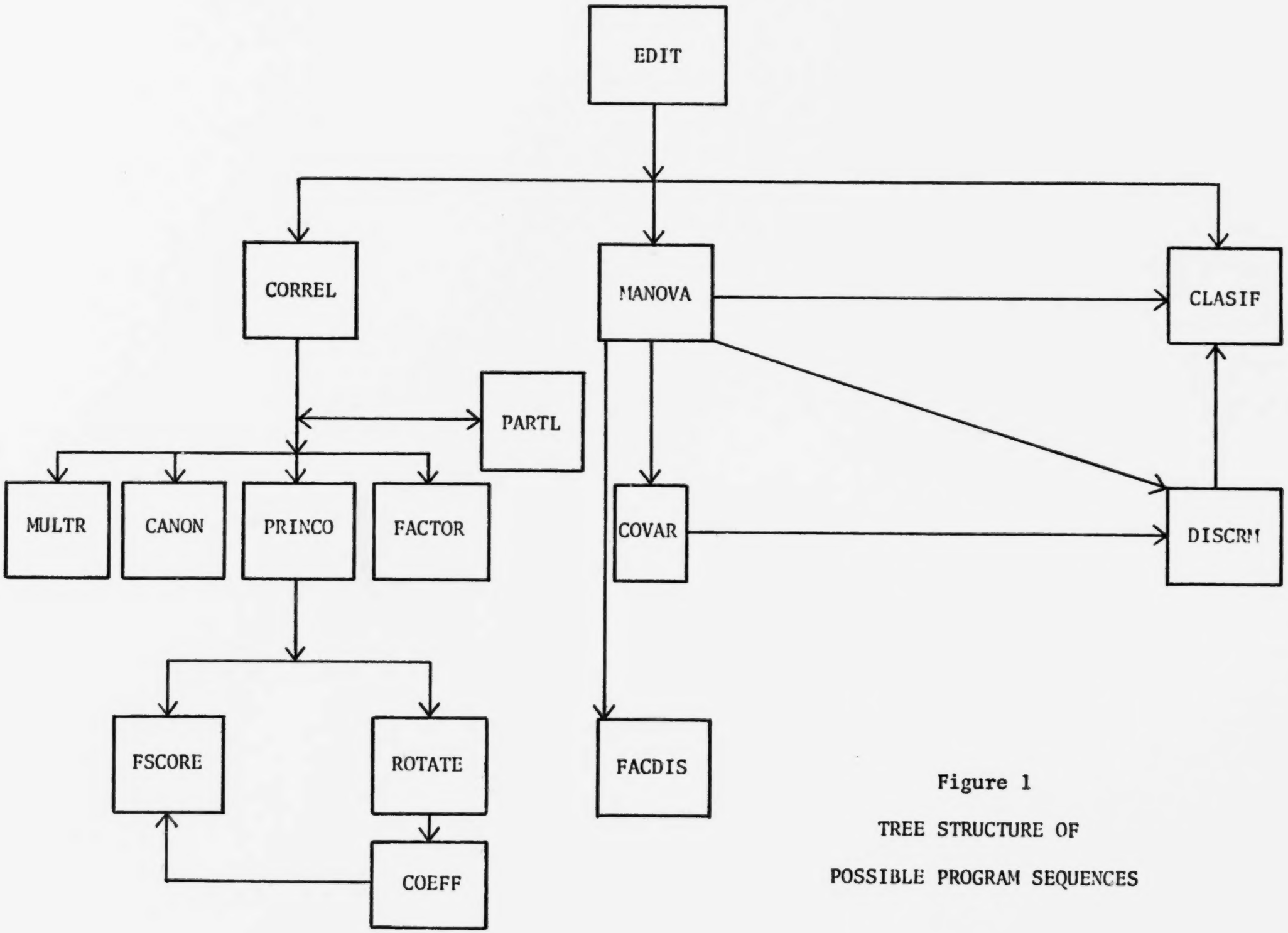

Figure 1

TREE STRUCTURE OF

POSSIBLE PROGRAM SEQUENCES

```
>$$logon 168wwc, size=32000.
M:ENTER PASSWORD
```



```
  ACCEPTED
M:  See $$explain schedule about March 13.
Ready:
>$$size = 32000.
>$$load d met.

MONTE CARLO ON T TEST

TYPE A 3 DIGIT NUMBER (200 OR SMALLER) GIVING THE NUMBER OF SAMPLE PAIRS
TO BE DRAWN
>200

TYPE A 2 DIGIT NUMBER (10 OR SMALLER) GIVING THE SIZE OF EACH SAMPLE
>08

BOTH POPULATIONS SAMPLED HAVE UNIT VARIANCE BUT MEANS MAY BE MADE TO DIFFER
TYPE 4 CHARACTERS (WITH DECIMAL) BETWEEN -2.0 AND +2.0, INDICATING DESIRED
DIFFERENCE
>0.0

TYPE IN ANY EIGHT DIGIT "RANDOM" NUMBER TO START THE RANDOM GENERATOR.
>68940215

     ******* DISTRIBUTION OF T'S *******


THE MEAN =      0.0771

THE STANDARD DEVIATION =      1.0330

THE VARIANCE =      1.0671

     FREQUENCY AND CUMULATIVE FREQUENCY DISTRIBUTION

  INTERVAL      LOWER LIMIT      FREQUENCY      CUM. FREQ.

        1          -99.000          0              0
        2           -3.333          0              0
        3           -3.000          0              0
        4           -2.667          2              2
        5           -2.333          5              7
        6           -2.000          6             13
        7           -1.667          7             20
        8           -1.333          5             25
        9           -1.000         17             42
       10           -0.667         24             66
       11           -0.333         32             98
       12            0.000         16            114
       13            0.333         33            147
       14            0.667         17            164
       15            1.000         12            176
       16            1.333         16            192
       17            1.667          4            196
       18            2.000          1            197
       19            2.333          0            197
       20            2.667          2            199
       21            3.000          0            199
       22            3.333          1            200

TRY RUNNING THIS PROGRAM AGAIN WHEN THE NULL HYPOTHESIS IS FALSE
```

```
>$$det all.
>$$p
>$$list mydata.
 14.       12.
 12.       16.
 11.       15.
 07.       11.
 06.       08.
 05.       10.
 08.       16.
 03.       09.
 09.       13.
>$$det all.
>$$att d mydata as F8.
>$$load d studat.
LOADING STARTS AT LOG 060200
EXTERNAL SYMBOL TABLE


CORRELATION ANALYSIS OF STUDENT'S DATA


SUPPLY THE NUMBER OF SUBJECTS ON THE DATASET YOU HAVE ATTACHED
AS A 3-DIGIT INTEGER.
>009


SUPPLY THE NUMBER OF VARIABLES CONTAINED ON THE DATASET YOU HAVE
ATTACHED AS A 1-DIGIT INTEGER BETWEEN 2 AND 8.
>2


CORRELATION ANALYSIS BETWEEN VARIABLES 1 AND 2 FOR 9 SUBJECTS.

          VARIABLE 1    .                  VARIABLE 2

          MEAN      =     8.333            MEAN      =     12.222
          VARIANCE  =    12.500            VARIANCE  =      8.944
          ST DEV    =     3.5355           ST DEV    =      2.9907
                 CORRELATION COEFFICIENT R = 0.654

                 R-SQUARED = 0.4279

                 Z-SCORE STANDARD ERROR ESTIMATE = 0.7564

                 T CALCULATED FROM ABOVE R:

                      T = 2.288 WITH NDF = 7
WOULD YOU LIKE TO TRY THIS PROGRAM AGAIN?
>no
WHEN YOU HAVE COMPLETED YOUR WORK AT THE TERMINAL, BE SURE TO TYPE $$LOGOFF.
"SEE YOU NEXT WEEK!"
```

```
>$$att d tandw as F7.
>$$att d means as F8.
>$$att disk as F9.
>$$load d main.
LOADING STARTS AT LOC 088200
EXTERNAL SYMBOL TABLE
  MAIN          0

MULTIPLE DISCRIMINANT ANALYSIS, COMPILED 21 JAN 69


SUPPLY THE NUMBER OF VARIABLES AS A TWO DIGIT INTEGER NOT GREATER THAN 20.
> 2


SUPPLY THE NUMBER OF GROUPS AS A TWO DIGIT INTEGER NOT GREATER THAN 20.
> 3


SUPPLY THE NUMBER OF SUBJECTS AS A 4 DIGIT INTEGER.
> 196


SUPPLY THE NUMBER OF CONTROL VARIABLES PREVIOUSLY PARTIALED OUT BY
COVAR AS A TWO DIGIT INTEGER.
>00


 F-RATIO FOR H2, OVERALL DISCRIMINATION, =      2.15

 NDF1 =     4 AND NDF2 =     384

 CHI-SQUARE TESTS WITH SUCCESSIVE ROOTS REMOVED
```


ROOTS REMOVED	CANONICAL R	R SQUARED	EJGENVALUE	CHI SQUARE	NDF	LAMBDA	PERCENT TRACE
0	0.208	0.043	0.045	8.51	6	0.96	99.87
1	0.008	0.000	0.000	0.01	2	1.00	0.13

```
 ROW COEFFICIENTS VECTORS

 D F   1        0.0043032        0.0494752
 D F   2       -0.0557285        0.0978380

 FACTOR PATTERN FOR DISCRIMINANT FUNCTIONS

TEST

   1      0.888      -0.449
   2      0.992       0.077

COMMUNALITIES FOR       2 DISCRIMINANT FACTORS
   1       0.990       2       0.990

PERCENTAGE OF TRACE OF R ACCOUNTED FOR BY EACH ROOT

   1.88.611       2 10.372
```

ONR Distribution List

NAVY

4 Chief of Naval Research
Code 458
Department of the Navy
Washington, D. C. 20360

1 Director
ONR Branch Office
495 Summer Street
Boston, Massachusetts 02210

1 Director
ONR Branch Office
219 South Dearborn Street
Chicago, Illinois 60604

1 Director
ONR Branch Office
1030 East Green Street
Pasadena, California 91101

1 Contract Administrator
Southeastern Area
Office of Naval Research
2110 "G" Street, N. W.
Washington, D. C. 20037

6 Director
Naval Research Laboratory
Attn: Library, Code 2029 (ONRL)
Washington, D. C. 20390

1 Office of Naval Research
Area Office
207 West Summer Street
New York, New York 10011

1 Office of Naval Research
Area Office
1076 Mission Street
San Francisco, California 94103

20 Defense Documentation Center
Cameron Station, Building 5
5010 Duke Street
Alexandria, Virginia 22314

1 Superintendent
Naval Postgraduate School
Monterey, California 93940
Attn: Code 2124

1 Head, Psychology Branch
Neuropsychiatric Service
U. S. Naval Hospital
Oakland, California 94627

1 Commanding Officer
Service School Command
U. S. Naval Training Center
San Diego, California 92133

1 Commanding Officer
Naval Personnel & Training
Research Laboratory
San Diego, California 92152

1 Officer in Charge
Naval Medical Neuropsychiatric
Research Unit
San Diego, California 92152

NAVY

1 Commanding Officer
Naval Air Technical Training Center
Jacksonville, Florida 32213

1 Dr. James J. Regan
Naval Training Device Center
Orlando, Florida 32813

1 Chief
Aviation Psychology Division
Naval Aerospace Medical Institute
Naval Aerospace Medical Center
Pensacola, Florida 32512

1 Chief
Naval Air Reserve Training
Naval Air Station
Box 1
Glenview, Illinois 60026

1 Technical Library
U. S. Naval Weapons Laboratory
Dahlgren, Virginia 22448

1 Chairman
Leadership/Management Committee
Naval Sciences Department
U. S. Naval Academy
Annapolis, Maryland 21402

1 Dr. A. L. Slafkosky
Scientific Advisor
Commandant of the Marine Corps
(Code AX)
Washington, D. C. 20380

1 Technical Services Division
National Library of Medicine
8600 Rockville Pike
Bethesda, Maryland 20014

1 Behavioral Sciences Department
Naval Medical Research Institute
National Naval Medical Center
Bethesda, Maryland 20014

1 Commanding Officer
Naval Medical Field Research Laboratory
Camp Lejeune, North Carolina 28542

1 Director
Aerospace Crew Equipment Department
Naval Air Development Center, Johnsville
Warminster, Pennsylvania 18974

1 Chief
Naval Air Technical Training
Naval Air Station
Memphis, Tennessee 38115

1 Technical Library
Naval Training Device Center
Orlando, Florida 32813

1 Technical Library
Naval Ship Systems Command
Main Navy Building, Rm. 1532
Washington, D. C. 20360

1 Technical Library
Naval Ordnance Station
Indian Head, Maryland 20640

1 Naval Ship Engineering Center
Philadelphia Division
Technical Library
Philadelphia, Pennsylvania 19112

1 Library, Code 0212
Naval Postgraduate School
Monterey, California 93940

NAVY

1 Technical Reference Library
Naval Medical Research Institute
National Naval Medical Center
Bethesda, Maryland 20014

1 Technical Library
Naval Ordnance Station
Louisville, Kentucky 40214

1 Library
Naval Electronics
Laboratory Center
San Diego, California 92152

1 Technical Library
Naval Undersea Warfare Center
3202 E. Foothill Boulevard
Pasadena, California 91107

1 AFHRL (HRTT/Dr. Ross L. Morgan)
Wright-Patterson Air Force Base
Ohio 45433

1 AFHRL (HRO/Dr. Meyer)
Brooks Air Force Base
Texas 78235

1 Mr. Michael Macdonald-Ross
Instructional Systems Associates
West One
49 Welbeck Street
London W1M 7HE
England

1 Commanding Officer
U. S. Naval Schools Command
Mare Island
Vallejo, California 94592

1 Dr. Don C. Coombs
Assistant Director
ERIC Clearinghouse
Stanford University
Palo Alto, California 94305

1 Scientific Advisory Team (Code 71)
Staff, COMASWFORLANT
Norfolk, Virginia 23511

1 ERIC Clearinghouse
Educational Media and Technology
Stanford University
Stanford, California

1 ERIC Clearinghouse
Vocational and Technical Education
Ohio State University
Columbus, Ohio 43212

1 Education & Training Developments Staff
Personnel Research & Development Lab.
Building 200, Washington Navy Yard
Washington, D. C. 20390

1 Director
Education & Training Sciences Dept.
Naval Medical Research Institute
Building 142
National Naval Medical Center
Bethesda, Maryland 20014

1 LCDR J. C. Meredith, USM (Ret.)
Institute of Library Research
University of California, Berkeley
Berkeley, California 94720

1 Mr. Joseph B. Blankenheim
NAVELEX 0474
Munitions Building, Rm. 3721
Washington, D. C. 20360

NAVY

1 Commander
Operational Test &
Evaluation Force
U. S. Naval Base
Norfolk, Virginia 23511

1 Office of Civilian
Manpower Management
Department of the Navy
Washington, D. C. 20350
Attn: Code 023

1 Chief of Naval Operations, Op-07TL
Department of the Navy
Washington, D. C. 20350

1 Chief of Naval Material
(MAT 031M)
Room 1323, Main Navy Bldg.
Washington, D. C. 20360

1 Naval Ship Systems Command
Code 03H
Department of the Navy
Main Navy Building
Washington, D. C. 20360

1 Chief
Bureau of Medicine and Surgery
Code 513
Washington, D. C. 20390

1 Technical Library
Bureau of Naval Personnel
(Pers-11b)
Department of the Navy
Washington, D. C. 20370

1 Director
Personnel Research &
Development Laboratory
Washington Navy Yard, Building 200
Washington, D. C. 20390

1 Commander, Naval Air Systems Command
Navy Department, AIR-4133
Washington, D. C. 20360

1 Commandant of the Marine Corps
Headquarters, U. S. Marine Corps
Code A01B
Washington, D. C. 20380

ARMY

1 Human Resources Research Office
Division #6, Aviation
Post Office Box 428
Fort Rucker, Alabama 36360

1 Human Resources Research Office
Division #3, Recruit Training
Post Office Box 5787
Presidio of Monterey, California 93940
Attn: Library

1 Human Resources Research Office
Division #4, Infantry
Post Office Box 2086
Fort Benning, Georgia 31905

1 Department of the Army
U. S. Army Adjutant General School
Fort Benjamin Harrison, Ind. 46216
Attn: AGCS-EA

ARMY

1 Director of Research
U. S. Army Armor
Human Research Unit
Fort Knox, Kentucky 40121
Attn: Library

1 Research Analysis Corporation
McLean, Virginia 22101
Attn: Library

1 Human Resources Research Office
Division #5, Air Defense
Post Office Box 6021
Fort Bliss, Texas 79916

1 Human Resources Research Office
Division #1, Systems Operations
300 North Washington Street
Alexandria, Virginia 22314

1 Director
Human Resources Research Office
The George Washington University
300 North Washington Street
Alexandria, Virginia 22314

1 Armed Forces Staff College
Norfolk, Virginia 23511
Attn: Library

1 Chief
Training and Development Division
Office of Civilian Personnel
Department of the Army
Washington, D. C. 20310

1 U. S. Army Behavioral Science
Research Laboratory
Washington, D. C. 20315

1 Walter Reed Army Institute of Research
Walter Reed Army Medical Center
Washington, D. C. 20012

1 Behavioral Sciences Division
Office of Chief of Research
and Development
Department of the Army
Washington, D. C. 20310

1 Dr. George S. Harker
Director, Experimental Psychology Div.
U. S. Army Medical Research Laboratory
Fort Knox, Kentucky 40121

AIR FORCE

1 Director
Air University Library
Maxwell Air Force Base
Alabama 36112
Attn: AUL-8110

1 Cadet Registrar
U. S. Air Force Academy
Colorado 80840

1 Headquarters, ESD
ESVPT
L. G. Hanscom Field
Bedford, Massachusetts 01731
Attn: Dr. Mayer

1 AFHRL (HRT/Dr. G. A. Eckstrand)
Wright-Patterson Air Force Base
Ohio 45433

AIR FORCE

1 Commandant
U. S. Air Force School of Aerospace Medicine
Brooks Air Force Base, Texas 78235
Attn: Aeromedical Library (SMSDL)

1 6570th Personnel Research Laboratory
Aerospace Medical Division
Lackland Air Force Base
San Antonio, Texas 78236

1 AFOSR (SRLB)
1400 Wilson Boulevard
Arlington, Virginia 22209

1 Research Psychologist
SCBB, Headquarters
Air Force Systems Command
Andrews Air Force Base
Washington, D. C. 20331

1 Headquarters, U. S. Air Force
Chief, Analysis Division (AFPDPL)
Washington, D. C. 20330

1 Headquarters, U. S. Air Force
Washington, D. C. 20330
Attn: AFPTRTB

1 Headquarters, U. S. Air Force
AFRDDG
Room 1D373, The Pentagon
Washington, D. C. 20330

1 Headquarters, USAF (AFPTRD)
Training Devices and Instructional Technology Division
Washington, D. C. 20330

MISCELLANEOUS

1 Dr. Alvin E. Goins, Executive Secretary
Personality & Cognition Research Review Committee
Behavioral Sciences Research Branch
National Institute of Mental Health
5454 Wisconsin Avenue, Room 10A11
Chevy Chase, Maryland 20203

1 Dr. Mats Bjorkman
University of Umea
Department of Psychology
Umea 6, Sweden

1 Technical Information Exchange
Center for Computer Sciences and Technology
National Bureau of Standards
Washington, D. C. 20234

1 Director
Defense Atomic Support Agency
Washington, D. C. 20305
Attn: Technical Library

1 Executive Secretariat
Interagency Committee on Manpower Research
Room 515
1738 "M" Street, N. W.
Washington, D. C. 20036
(Attn: Mrs. Ruth Relyea)

1 Mr. Joseph J. Cowan
Chief, Personnel Research Branch
U. S. Coast Guard Headquarters
PO-1, Station 3-12
1300 "E" Street, N. W.
Washington, D. C. 20226

MISCELLANEOUS

1 Executive Officer
American Psychological Association
1200 Seventeenth Street, N. W.
Washington, D. C. 20036

1 Mr. Edmund C. Berkeley
Information International, Inc.
545 Technology Square
Cambridge, Massachusetts 02139

1 Dr. Donald L. Bitzer
Computer-Based Education Research Laboratory
University of Illinois
Urbana, Illinois 61801

1 Dr. C. Victor Bunderson
Computer Assisted Instruction Lab.
University of Texas
Austin, Texas 78712

1 Dr. F. J. DiVesta
Education & Psychology Center
Pennsylvania State University
University Park, Pennsylvania 16802

1 Dr. Phillip H. DuBois
Department of Psychology
Washington University
Lindell & Skinker Boulevards
St. Louis, Missouri 63130

1 Dr. Wallace Feurzeig
Bolt, Beranek & Newman, Inc.
50 Moulton Street
Cambridge, Massachusetts 02138

1 Dr. Bert Green
Department of Psychology
John Hopkins University
Baltimore, Maryland 21218

1 Dr. J. P. Guilford
University of Southern California
3551 University Avenue
Los Angeles, California 90007

1 Dr. Harold Gulliksen
Department of Psychology
Princeton University
Princeton, New Jersey 08540

1 Dr. Duncan N. Hansen
Center for Computer Assisted Instruction
Florida State University
Tallahassee, Florida 32306

1 Dr. Albert E. Hickey
Entelek, Incorporated
42 Pleasant Street
Newburyport, Massachusetts 01950

1 Dr. Howard H. Kendler
Department of Psychology
University of California
Santa Barbara, California 93106

1 Dr. Robert R. Mackie
Human Factors Research, Inc.
6780 Cortona Drive
Santa Barbara Research Park
Goleta, California 93107

MISCELLANEOUS

1 Dr. Henry S. Odbert
National Science Foundation
1800 "G" Street, N. W.
Washington, D. C. 20550

1 Dr. Gabriel D. Ofiesh
Center for Educational Technology
Catholic University
4001 Harewood Road, N. E.
Washington, D. C. 20017

1 Dr. Joseph W. Rigney
Electronics Personnel Research Group
University of Southern California
University Park
Los Angeles, California 90007

1 Dr. Arthur I. Siegel
Applied Psychological Services
Science Center
404 East Lancaster Avenue
Wayne, Pennsylvania 19087

1 Dr. Arthur W. Staats
Department of Psychology
University of Hawaii
Honolulu, Hawaii 96822

1 Dr. Lawrence M. Stolurow
Harvard Computing Center
6 Appian Way
Cambridge, Massachusetts 02138

1 Dr. Ledyard R. Tucker
Department of Psychology
University of Illinois
Urbana, Illinois 61801

1 Dr. Benton J. Underwood
Department of Psychology
Northwestern University
Evanston, Illinois 60201

1 Dr. Joseph A. Van Campen
Institute for Math Studies in the
Social Sciences
Stanford University
Stanford, California 94305

1 Dr. John Annett
Department of Psychology
Hull University
Yorkshire
England

1 Dr. M. C. Shelesnyak
Interdisciplinary Communications Program
Smithsonian Institution
1025 Fifteenth Street, N. W.
Suite 70[illegible]
Washing[illegible], D. C. 20005

1 Dr. Lee J. Cronbach
School of Education
Stanford University
Stanford, California 94305

1 Dr. John C. Flanagan
Applied Institutes for Research
P. O. Box 1113
Palo Alto, C[illegible]lifornia 94302

1 Dr. M. D. Havron
Human Sciences Research, Inc.
Westgate Industrial Park
7710 Old Springhouse Road
McLean, Virginia 22101

1 Dr. Roger A. Kaufman
Department of Education
Institute of Instructional System
Technology & Research
Chapman College
Orange, California 92666

Unclassified
Security Classification

DOCUMENT CONTROL DATA - R & D

Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY *(Corporate author)*
Learning Research and Development Center
University of Pittsburgh
Pittsburgh, Pennsylvania 15213

2a. REPORT SECURITY CLASSIFICATION

2b. GROUP

3. REPORT TITLE
Computer-Assisted Instruction in Statistics

4. DESCRIPTIVE NOTES *(Type of report and, inclusive dates)*
ONR Technical Report

5. AUTHOR(S) *(First name, middle initial, last name)*
William W. Cooley

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
1969	14 pp.	8 refs.

8a. CONTRACT OR GRANT NO.
Nonr-624(18)
b. PROJECT NO
c.
d.

9a. ORIGINATOR'S REPORT NUMBER(S)

9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)*

10. DISTRIBUTION STATEMENT
This document has been approved for public release and sale; its distribution is unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Personnel and Training Branch Psychological Sciences Division Office of Naval Research

13. ABSTRACT

The development of a computer-assisted laboratory in statistical inference is discribed. University of Pittsburgh students work on-line with the Pitt Time-Sharing System on two kinds of laboratory statistics exercises: Monte Carlo exercises for exploring sampling distributions and data analysis exercises. The computer system utilized, the student wxercises, and future plans for evaluation are discussed.

DD FORM 1 NOV 65 1473 (PAGE 1)
S/N 0101-807-6811

Unclassified
Security Classification

A-31408

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Computer-Assisted Instruction						
Statistics						